Lignin production using a two-stage dilute acid hydrolysis process: Evaluation as a binder for coal fines

K.C. Patrick Lee
Tennessee Valley Authority, Public Power Institute, CEB 1C-M, Muscle Shoals, Alabama 35662, U.S.A.
Fax: 256-386-2191; plee@tva.gov

Coal washing operations are standard methods used in removing pyritic sulfur from coal. The sulfur and ash components of the coal are separable when they have been liberated from the coal particles. One of the greatest drawbacks to these pre-combustion cleaning operations is the economic use of these coal fines. The particle size of the coal fines is very small and is usually less than 100 ?m. The fine coal fines particles are difficult to dewater and/or dry, as well as shipping, marketing, and utilization. Coal fines have a high energy content, but also a sulfur content that makes their sale marginal in light of the Clean Coal Regulations. Most coal fines are viewed as a waste material and are currently being landfilled/ponded onsite at a significant disposal cost. Environmental problems may also be associated with these methods of disposal since the sulfur is made more susceptible to runoff and surface water contamination.

In an effort to use the coal fines, pellets and briquettes were made and tested using a petroleum-based binder. The petroleum binders were unsuccessful because they produced a gummy buildup inside of the coal pulverizers. This sticky residue is an inherent characteristic of petroleum-based binders and resolution may not be possible. In addition, the petroleum-based binders produce air, water, ground, and other environmental regulatory problems that are inherent with petroleum-based products.

Ethanol production from cellulosic materials is viewed as a viable alternative in keeping up with the surging demand in ethanol for transportation. The added advantages are reduction in America's dependency on foreign oil, reduction in air pollutant and green house gas, and it's renewable when it is produced from grains and biomass. Many biomass wastes are currently being landfilled and not being utilized. The U.S. government supported the fundamental technology in biomass conversion technologies in the past, and it has increased its support of the biomass-to-ethanol effort in recent years. This will make the biomass-to-ethanol process more technological and economical feasible in the near future. One of the products of biomass-to-ethanol process is lignin. Because of the high energy content of lignin (ca. 8,500 Btu/lb), it is usually considered as a fuel in most biomass-to-ethanol biorefinery plant to supplement the power requirement. Besides, the intrinsic nature of lignin can make it a natural binder for coal fines. Lignin is nature's most abundant biomass substance with natural glue-like characteristics. These natural characteristics make it an ideal adhesive for encapsulating the coal fines. Once encapsulated, the coal fines can be processed in the existing coal handling facilities of a fossil plant.

The biomass conversion team at Tennessee Valley Authority has over 50 years of experience in the processing of biomass and conversion of biomass to ethanol. The dilute and concentrated acid hydrolysis processes have been piloted and demonstrated successfully at TVA's Muscle Shoals pilot facilities. In this paper, we will present the work on the production of lignin from southern hardwood using TVA's 4 tons/day dilute acid pilot facility. The pilot plant consists of a newly designed feed system that can handle a variety of feedstocks such as wood sawdust, wood chips, sugar cane bagasse, corn stover, and rice hulls; a zirconium hydrolyzer with direct and jacketed steam temperature control, a zirconium receiver, a screw press, and several filter presses. The equipment is controlled and monitored by a Foxboro system.

Southern hardwood sawdust and wood chips are purchased from a local chip mill. The sawdust is air dried at room temperature and the wood chips are used without further drying. Some tests are performed in the laboratory using the sawdust in a 2-gal Parr reactor that was made of Carpenter 20Cb alloy. The two-stage dilute acid hydrolysis process is used throughout these tests and the large-scale lignin production. The lignin obtained from the process is tested for various acid removal and dewatering techniques. The results of these are used in determining the optimum conditions for the lignin production in the pilot plant and dewatering.

Coal fines are obtained from the washing station located at one of TVA's fossil power plants. The coal fines are blended with the dewatered lignin at various concentrations. The lignin/coal fines blends are sent to vendors for pelletizing under various conditions. The effectiveness of the binding of coal fines with lignin residue is studied. Furthermore, combustion tests with these lignin/coal fines pellets are carried out, the emission and effect on the boiler are evaluated.